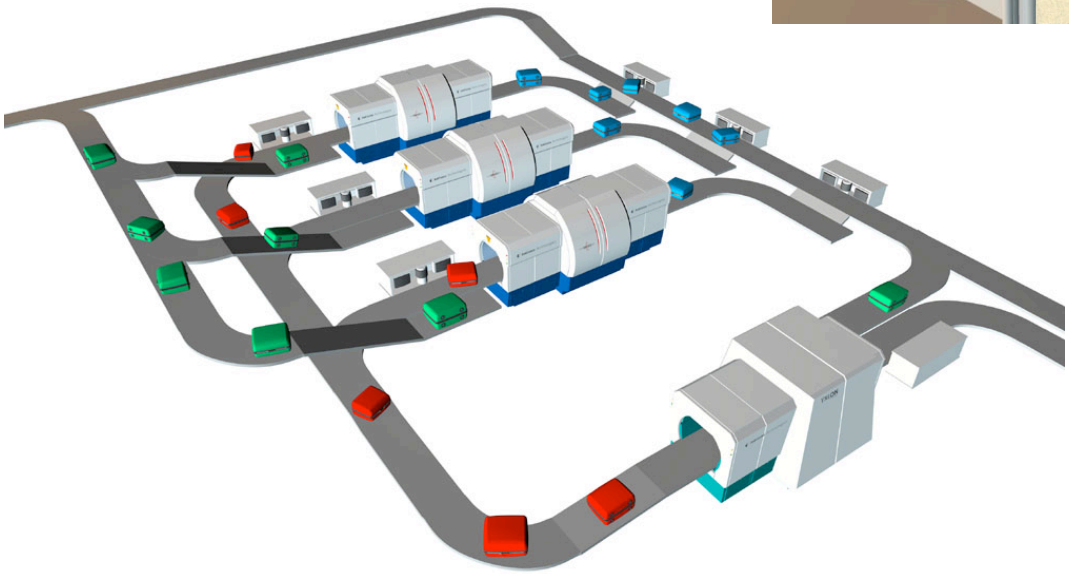
GE Security

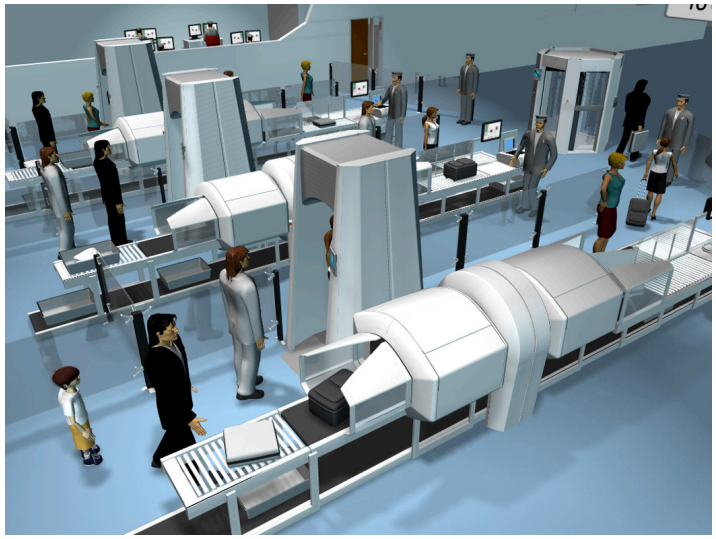
Building Checkpoints of the Future using Sensor Fusion

Yotam Margalit

imagination at work

Where is Sensor Fusion Going?





SRT Kiosk Concept of Operations

Modalities of Sensor Integration

Value Increases As
Standalone Matures
Into Sensor Fusion

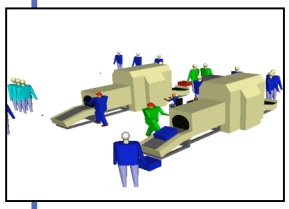
Security & Operations

Effort, Complexity & Cost

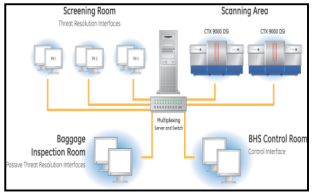
Standalone

Networked

Lobby EDS



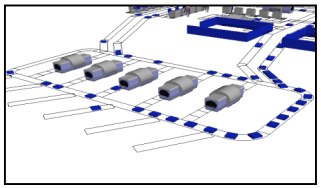
Multiplexing



Data Sharing

Sensor logic
altered by data
from other sensors

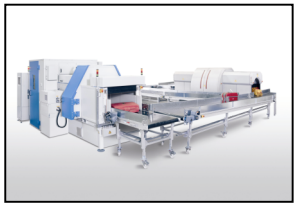
EDS BHS Int.



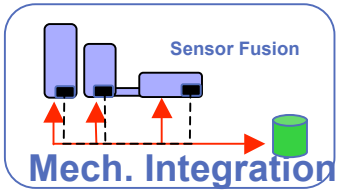
Data Fusion

Sensor physically
integrated

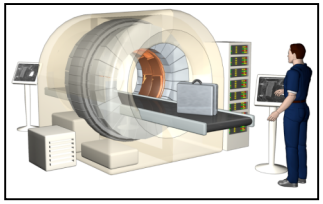
CTXRD



Mech. Integration



SCT-XRD



imagination at work

A *Generic* Example to Explain Sensor Fusion

The "Apple Detection System" (ADS)

- **The Purpose:**
  Find apples in a population of plastic balls, tomatoes, pears, apples, oranges, etc.

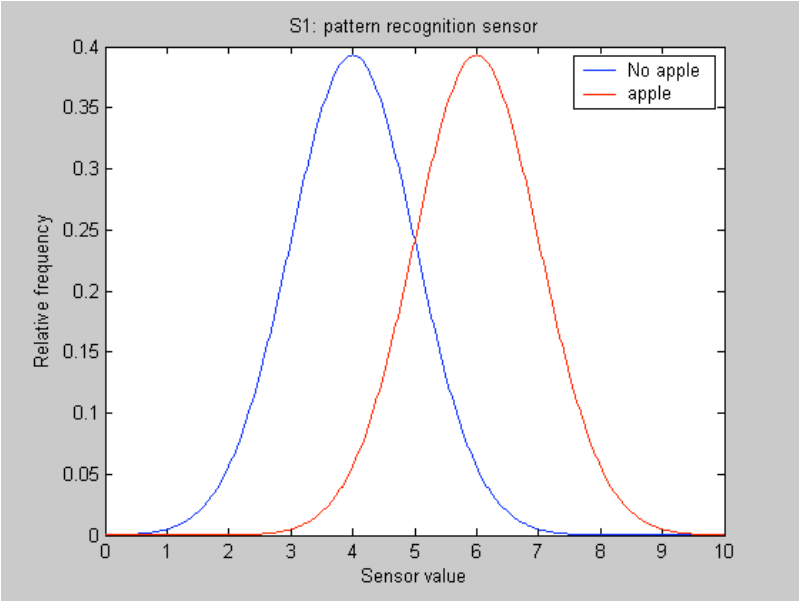
- **Main Features:**
  The ADS has two orthogonal sensors
  Sensor A = Image based; uses shape recognition.
  Sensor B = Chemical; PH sensor detecting apple acidity level.

Orthogonal Sensors
Scanners employ Orthogonal sensors when they measure different characteristics of the targets in order to determine the presence of explosives.

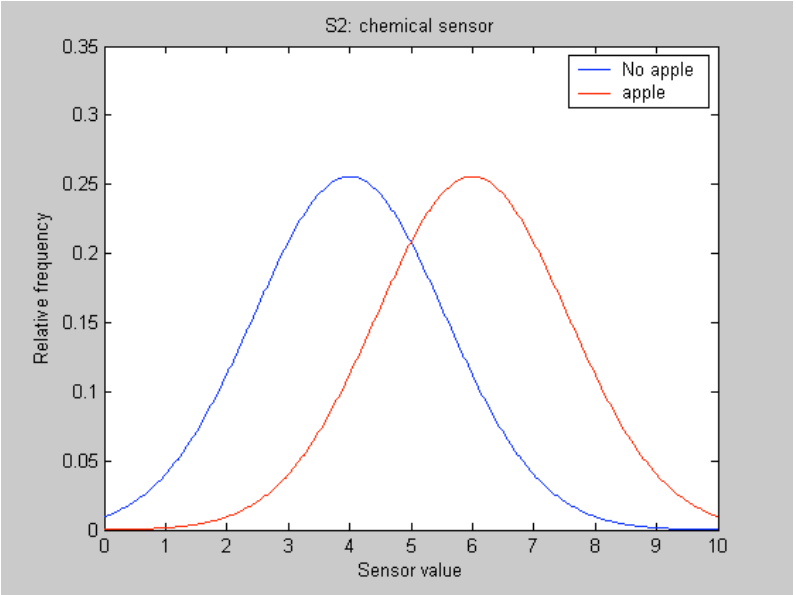
Studying Sensor behavior

- Each sensor generates a reading between 0 –10.
- Statistical data was collected, for each sensor individually, to create apples and non-apple population curves.

Sensor A: Image



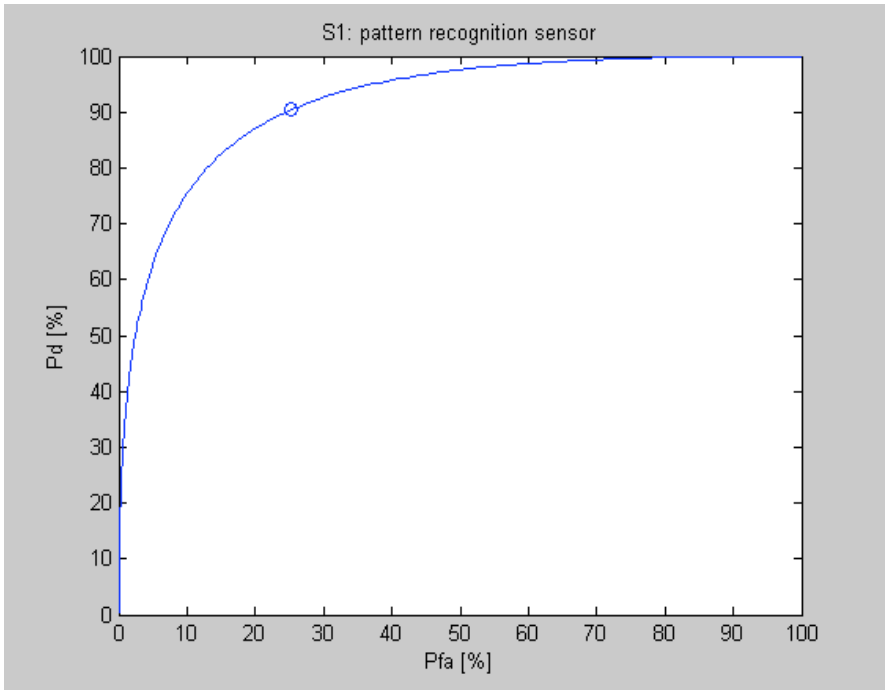
Sensor B: Chemical



Testing

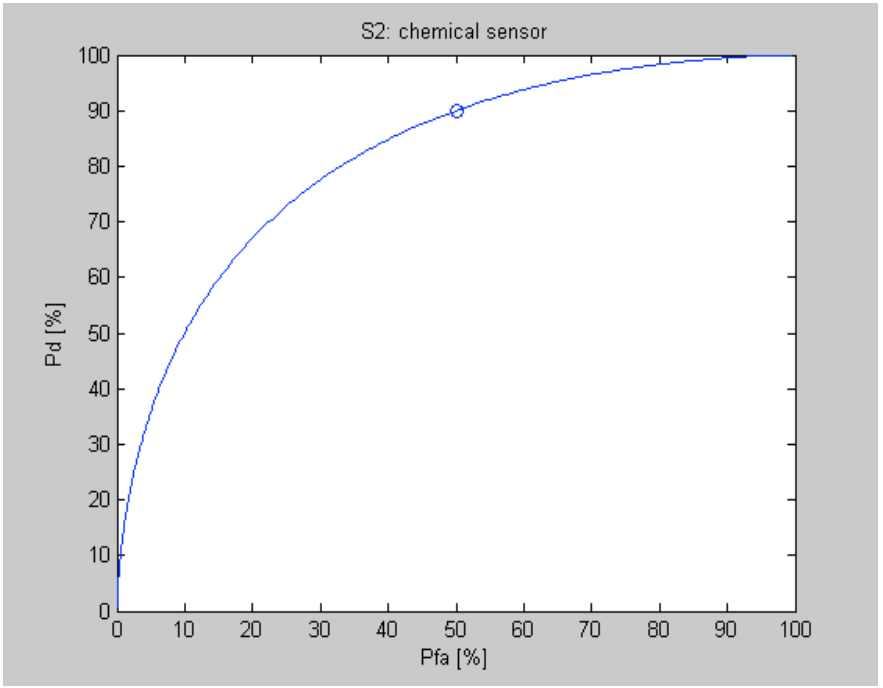
- Tests were conducted and the performance characteristics of Sensor A and Sensor B have been recorded.

Sensor A: Image



Pd = 90% Pfa = 25%

Sensor B: Chemical

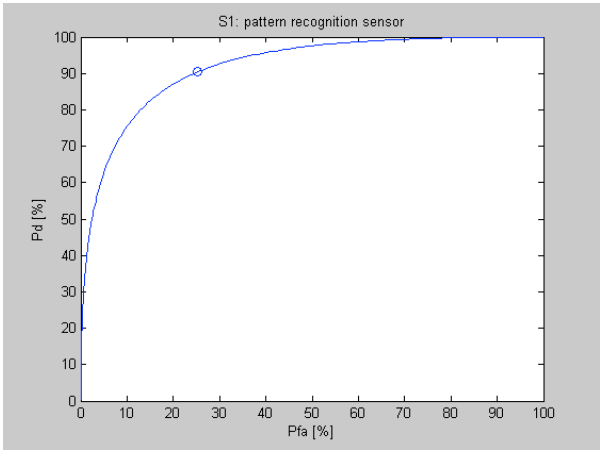


Pd = 90% Pfa = 50%

Option 1

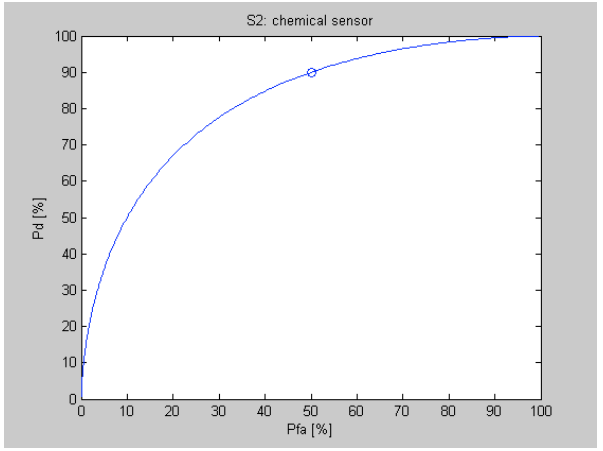
Use Sensors Individually and Independently

Sensor A: Image



Pd = 90% Pfa = 25%

Sensor B: Chemical

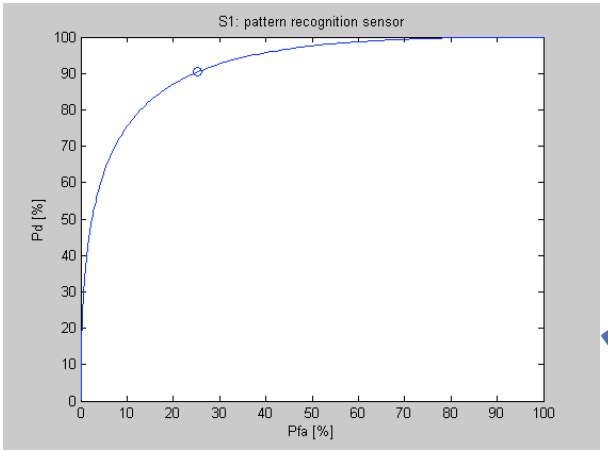


Pd = 90% Pfa = 50%

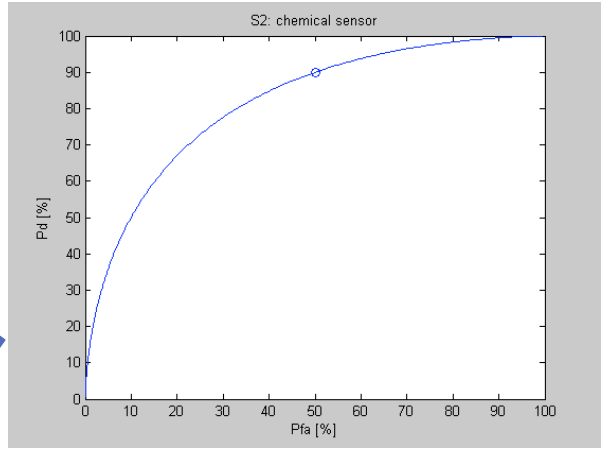
Option 2

Combine Sensor A and Sensor B with an “AND” Boolean

Sensor A:
Image



Sensor B:
Chemical



AND

$Pd = 90\%_{S1} \times 90\%_{S2} = 81\%$

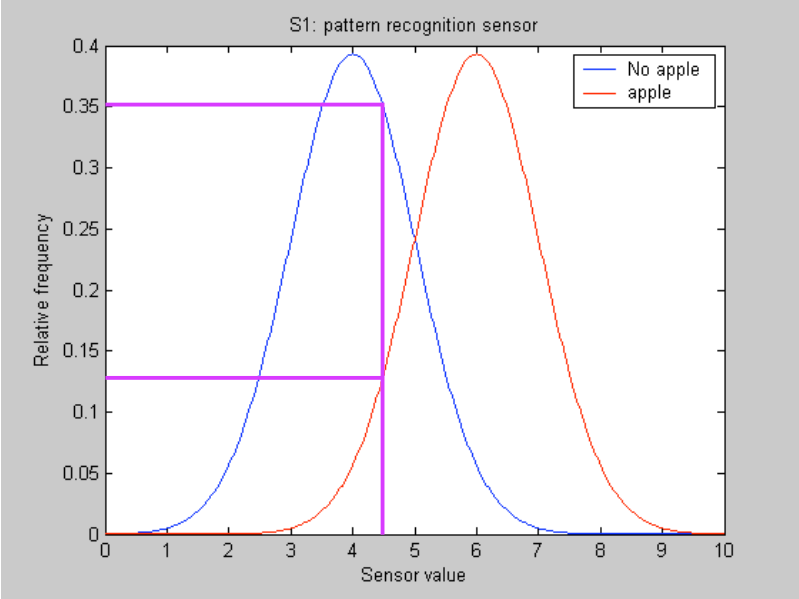
$Pfa = 25\%_{S1} \times 50\%_{S2} =$
12.5%

imagination at work

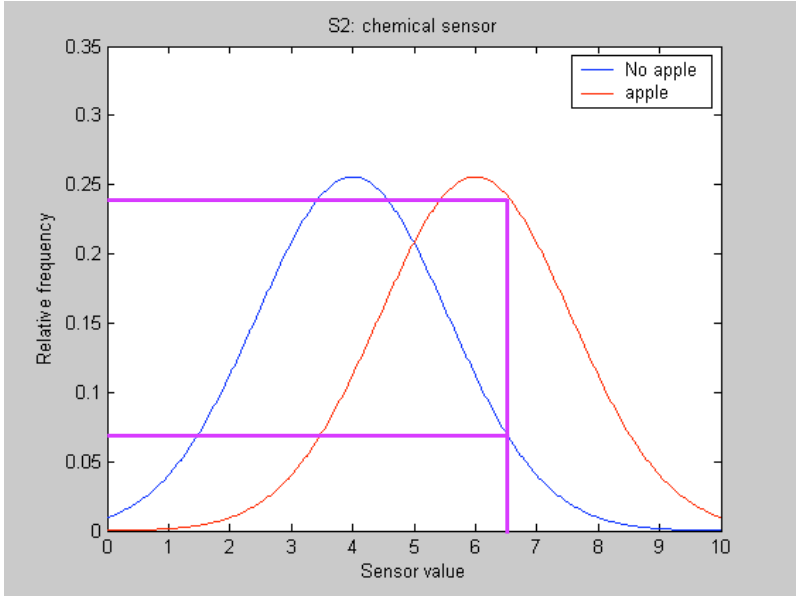
Option 3

Employ Data Fusion (Example: Bayesian)

Sensor A:
Image



Sensor B:
Chemical

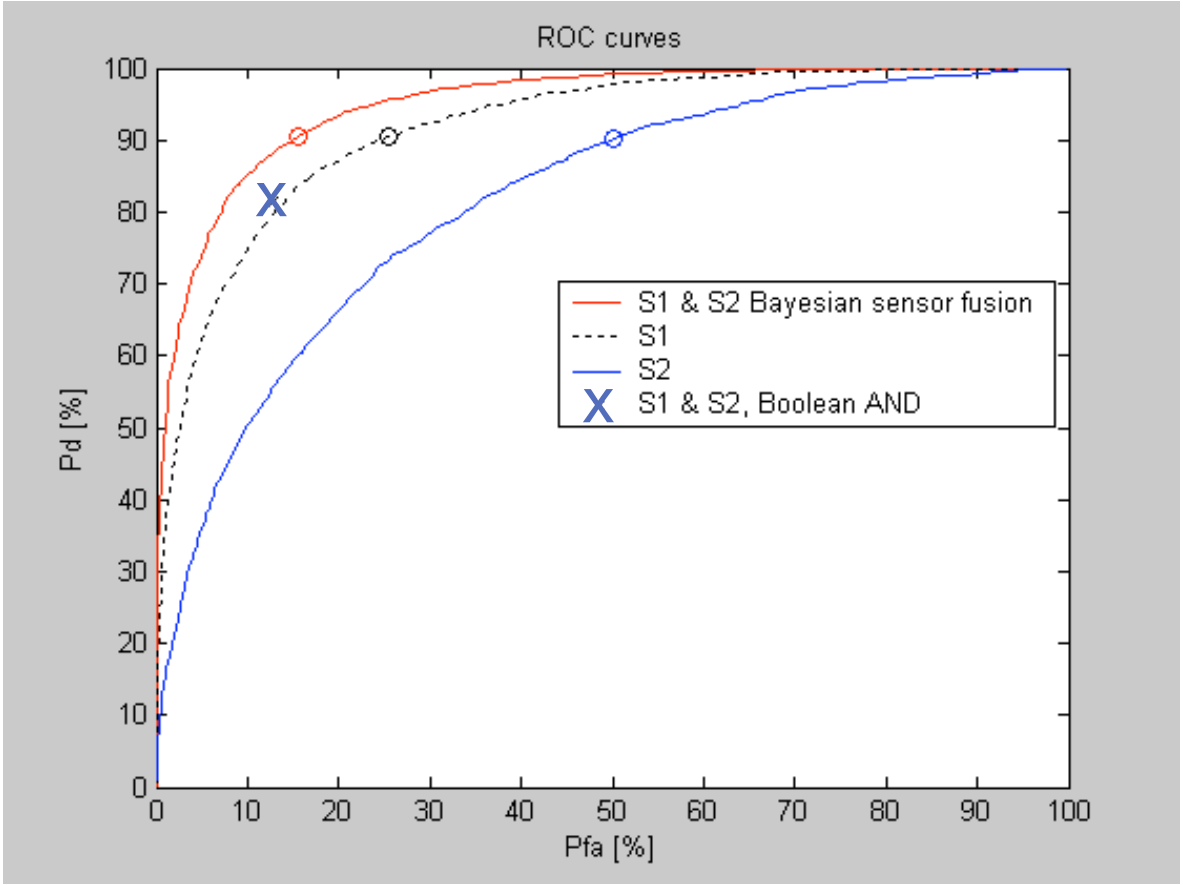


$$P(\text{Apple} \mid S1, S2) = \frac{P(S1 \mid \text{Apple})P(S2 \mid \text{Apple})P(\text{Apple})}{P(S1 \mid \text{Apple})P(S2 \mid \text{Apple})P(\text{Apple}) + P(S1 \mid \text{Other})P(S2 \mid \text{Other})P(\text{Other})}$$

Option 3 (continued)

Employ Data Fusion

ROC curve of data fusion:



Pd = 90%
Pfa = 14%

Performance Comparison Table

Method	Pd%	Pfa%
Image Sensor	90	25
Chemical Sensor	90	50
“AND” Boolean	81	12.5
Bayesian Sensor Fusion	90	14

Sensor Fusion – Where is the Hardware?

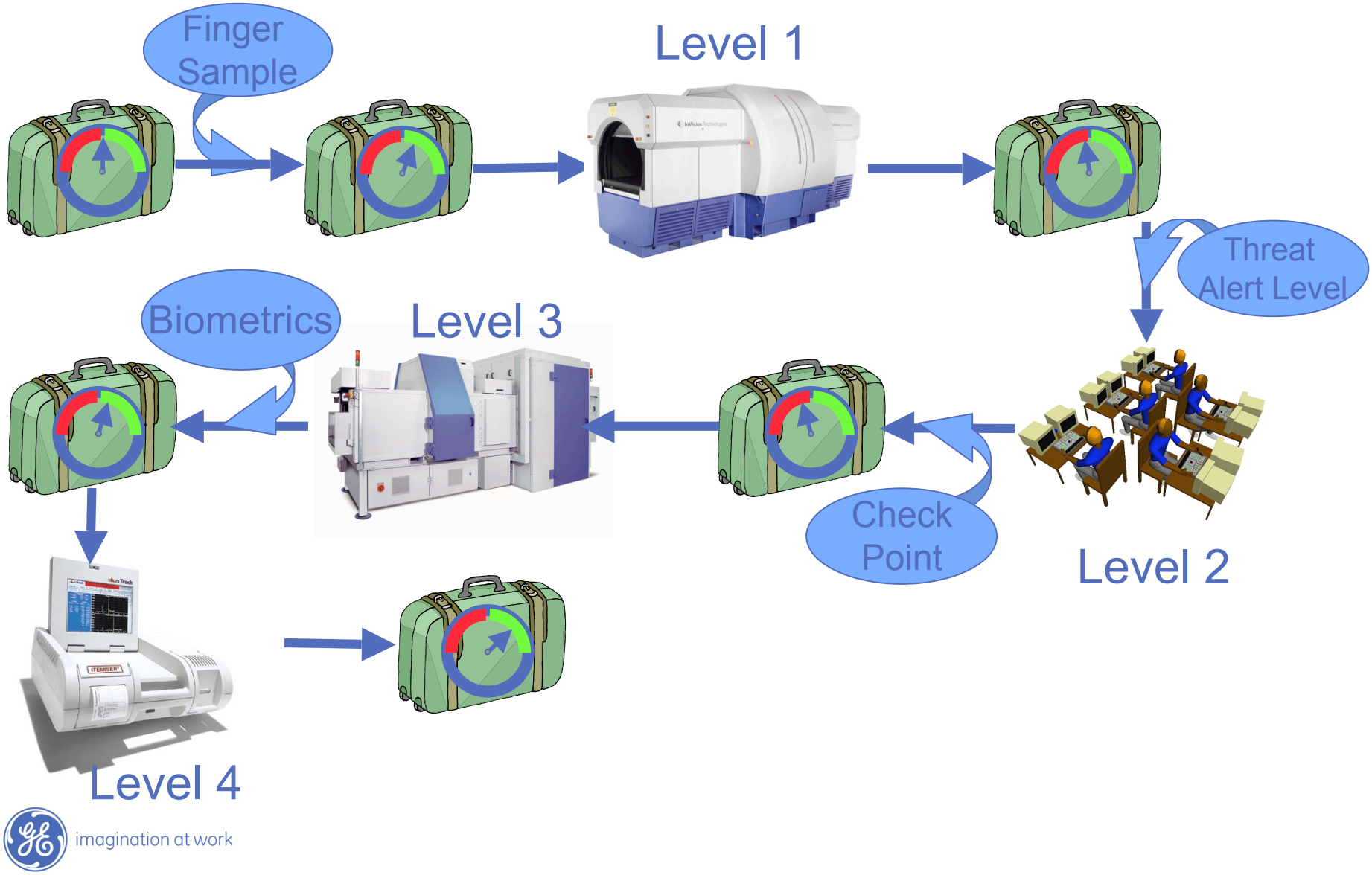
Threat Value Propagation

- Solve equation for each sensor separately
- Then "feed" the result to the next sensor to include in next steps of sensor fusion
- "DSFP" communications protocol

$$P(B \mid X) = \frac{P(X \mid B)P(B)}{P(X \mid B)P(B) + P(X \mid \overline{B})P(\overline{B})}$$

- "Threat Probability Meter"

Implementing Sensor Fusion



imagination at work

GE Security

Thank You

imagination at work